Plant Inspired Techniques For Distribution of Payload

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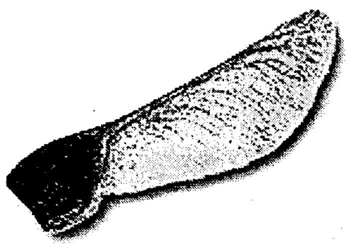
Plant World Inspired Payload Distribution Methods

- **Simpler and smaller than parachute on small scale for dispersion of sensors and small surveillance instruments.**
- **Controlled Descent Rate ~ 15 m/s (on surface of Mars)**



(a)
Maple Seed Samara

(b)
Dandelions

Design Goals:

- Small total mass, ~100 g
- High payload mass fraction, > 80%
- Captures key features of controlled and stable descent as observed in Samaras, such as maple seeds
- Reliable, minimal infrastructure
- unobstructed view overhead for atmospheric measurements
- simple construction, few constituent parts

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Seed Wing Mission Concept

- **Mission Objective**
  - Wide-area dispersion of in-situ surface chemical/mineralogical measurement to augment imagery
  - Atmospheric survey
  - Scouting for lander/rover mission planning (site selection), and preparation for sample return reconnaissance
- **Deployment**
  - Entry probe or airborne platform (glider, balloon, powered a/c)
- **Payloads**
  - MEMS sensors for chemistry, soil oxidation, or pH
  - Temperature and Pressure
- **Flight Profile**
  - Seed wings are sequentially deployed from another airborne platform (glider, balloon) or entry probe
  - Each seed wing autorotates to the surface, collecting atmospheric data (temperature and pressure)
  - After landing, each seed wing conducts a surface experiment using pyrotechnic or chemical test, which is analyzed using a MEMS sensor for presence of key trace elements. Also, the seed wing could deploy a biomorphic surface/subsurface explorer such as the worm robot
  - The orbiter or airborne platform emits a signal initiating sequential download of data from each seed wing. A phased array antenna is used to locate the source and recover the data

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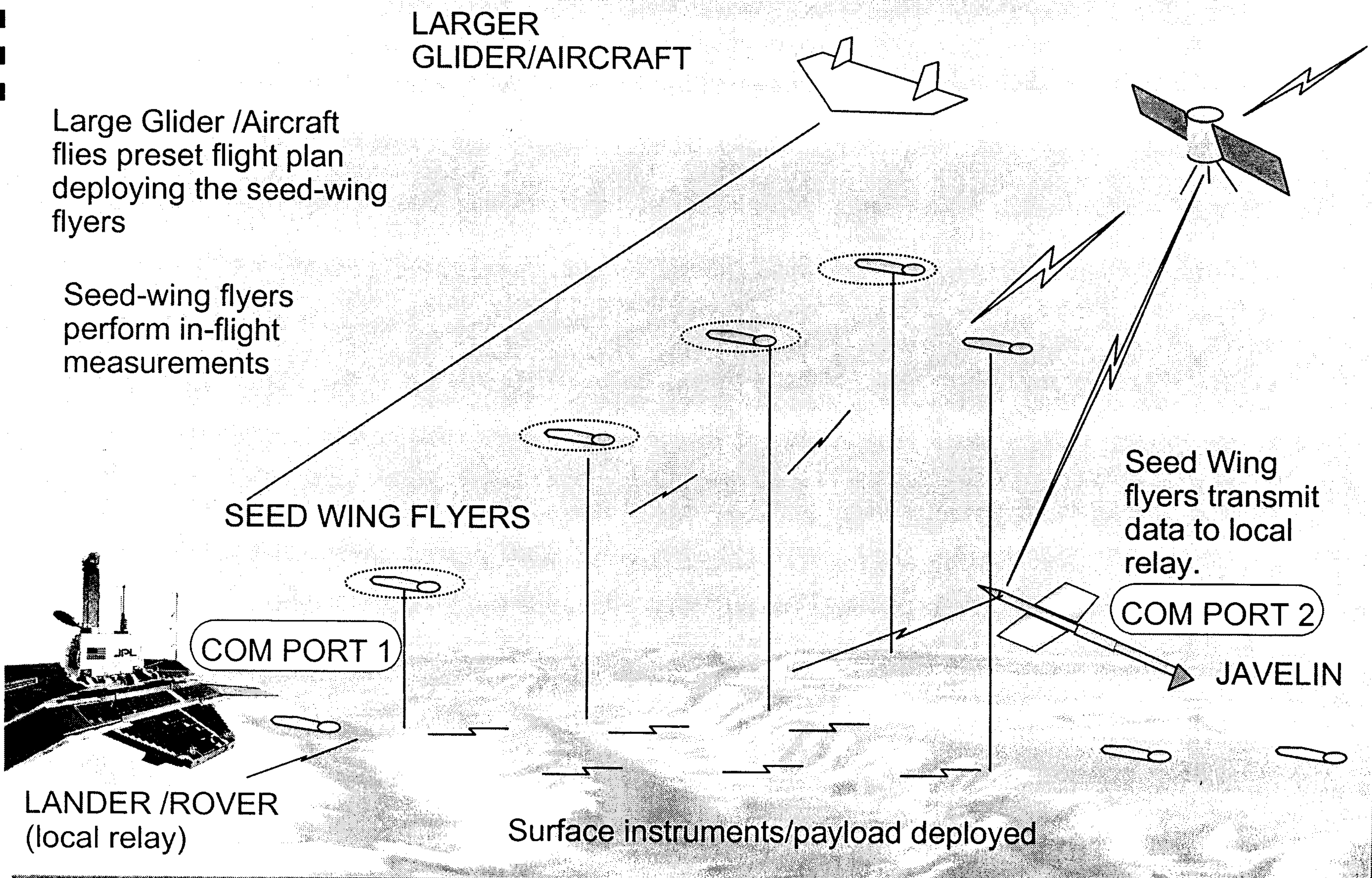

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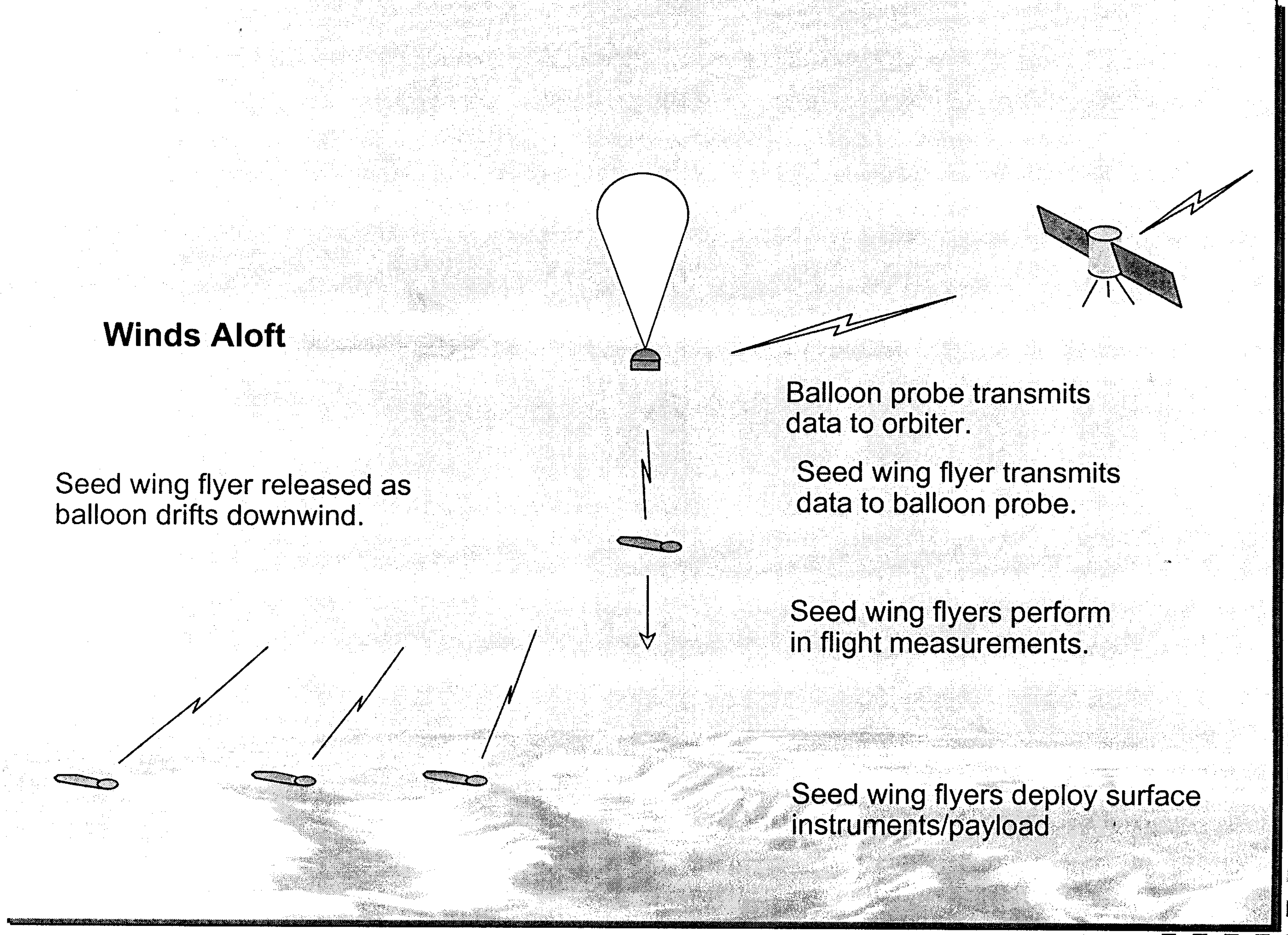

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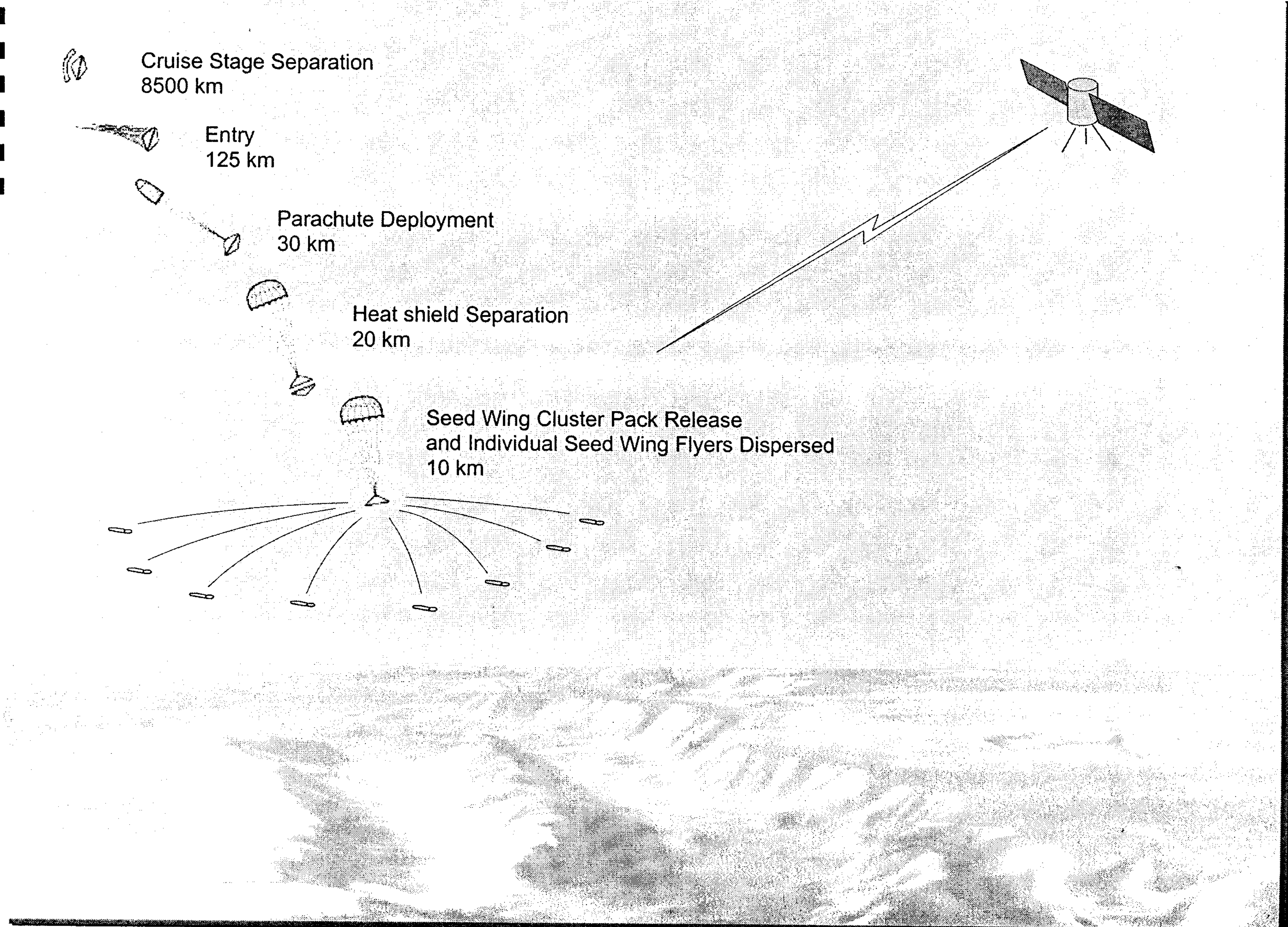
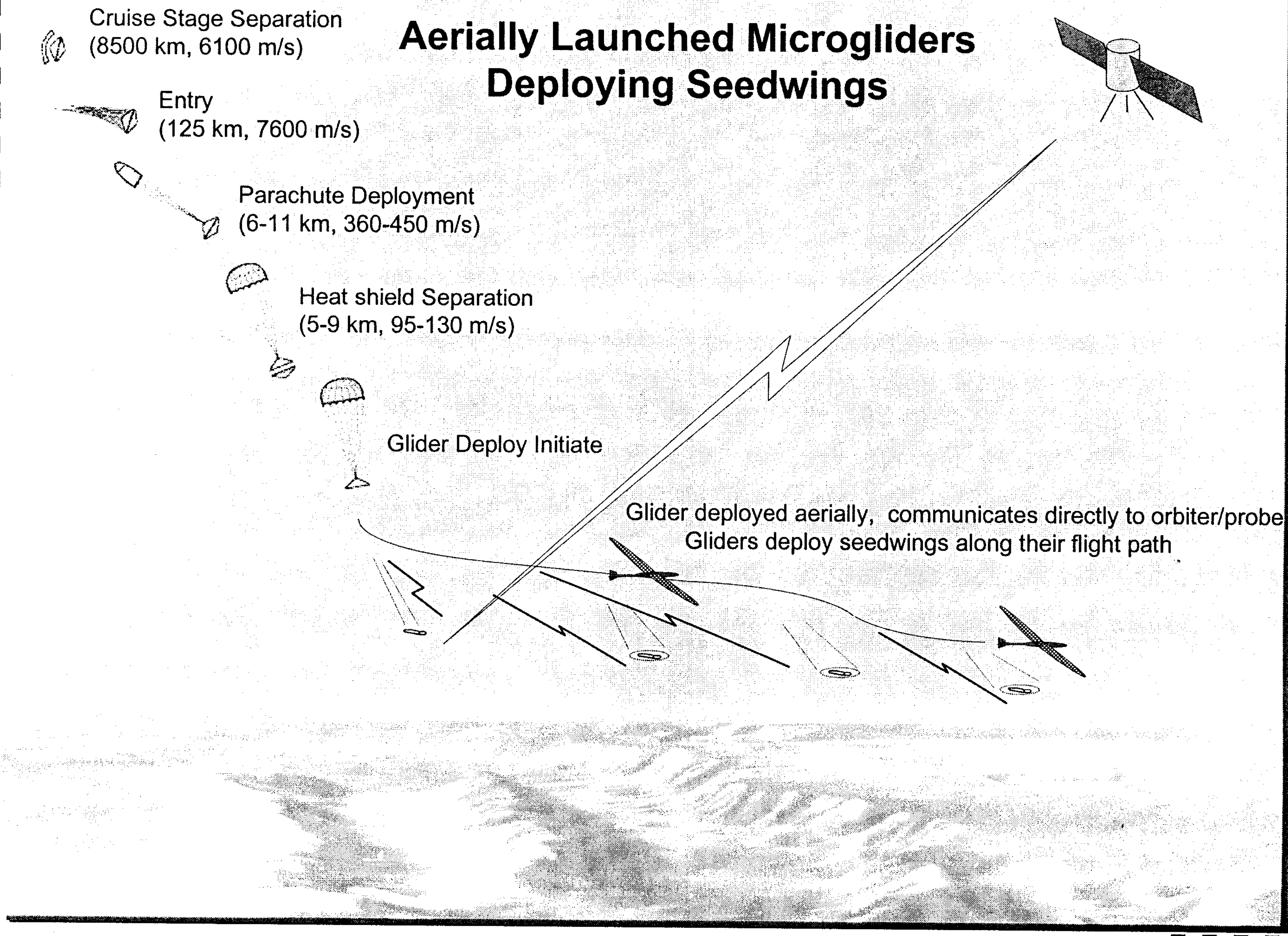


Aerially Launched Microgliders Deploying Seedwings



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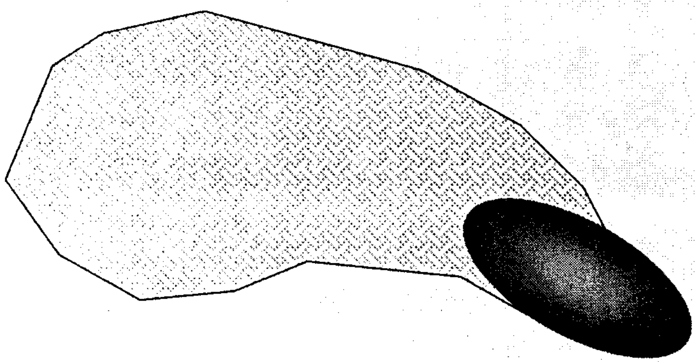
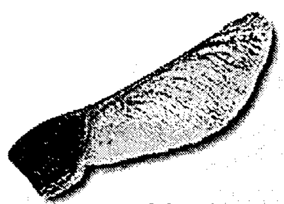
Seed Wing Flyers

- **Simpler and smaller than parachute on small scale for dispersion of sensors and small experiments.**
- **Payload mass fraction >80%.**



			Baseline		
Total Mass	=	40.0	60.0	250.0	g
Payload Mass	=	36.0	56.0	220.0	g
Payload Mass%	=	90	94	88	%
Blade Span	=	0.16	0.19	0.40	m
Swept Area	=	0.08	0.12	0.50	m^2
Volume	=	51	77	320	cm^3
Descent Rate	=	19	19	19	m/s
Duration	=	790	790	790	sec
Starting Alt.	=	10	10	10	km

- Performance calculations based on conditions at 5km altitude on Mars.



Maple seed

On earth a seed wing of the same size and shape would have the descent rate to be 1/6th of the corresponding value on Mars (~ 3 m/s). On earth for military applications we could trade some of the size and use a higher descent speed and still obtain safe delivery.

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Comparison of Biomorphic Flight System Concepts for Mars

Parameter		*Class* Powered μ Flyer	Glider	Seed Wing Flyer
Lift Generation		Wing	Wing	Rotating Wing
Method of Propulsion		Propeller	Gravity	Gravity
Energy Storage		Li Battery	Altitude	Altitude
Total Mass	(g)	57	57	57
Payload Mass (%)	(g)	**6 (~10 %)**	**32 (~ 50 %)**	**<u>52</u> (~ 90 %)**
Wing Span	(m)	0.19	0.19	0.19
Volume	(cm^3)	**380**	**230**	**<u>77</u>**
Flight Speed	(m/s)	84	84	19
Range	(km)	10	50	0
Duration	(s)	**120**	**700**	**<u>790</u>**
Starting Altitude	(km)	0	10	10

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Comparison with Parachute

Parameter	Seed Wing Flyer	Parachute
Lift generation	Rotating Wing	Drag
Method of Propulsion	Gravity	Gravity
Energy Storage	Altitude	Altitude
Payload Mass	Identical	Identical
Area Swept	Identical	Identical
Blade Span/Diameter	~ 0.55D	D
Descent Velocity	Vds	Vdp = 1.414 Vds
Duration of Descent	Tds	Tdp = 0.7 Tds
Shock on Impact	Ss	Sp = 2 Ss

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Biomorphic Controls in Seed Wing Flyers

Active control of seed wing descent is a significant concept for further development to impact the usefulness of seed wing flyers. This is an effort to influence the direction of descent, by periodic movement of a control surface on the wing portion. For example, a simple wing structural element made of advanced piezo-polymeric composite actuators could play a dual role as a structural member as well as an active control element when activated, altering the lift characteristics for a fraction of one rotation. The signal to drive the structural element would be generated by the measurement of sunlight on the upper payload surface. That signal would normally vary with rotation due to changing sun angle. Detection of a certain part of that periodic signal would be programmed to activate the change in wing shape. Thus, the seed wing would tend to move in a consistent pattern relative to the sun direction. Individual seed wings in an ensemble could be programmed to have varying solar response patterns, ensuring that the group travels away from each other, for maximum dispersion in the landing location.

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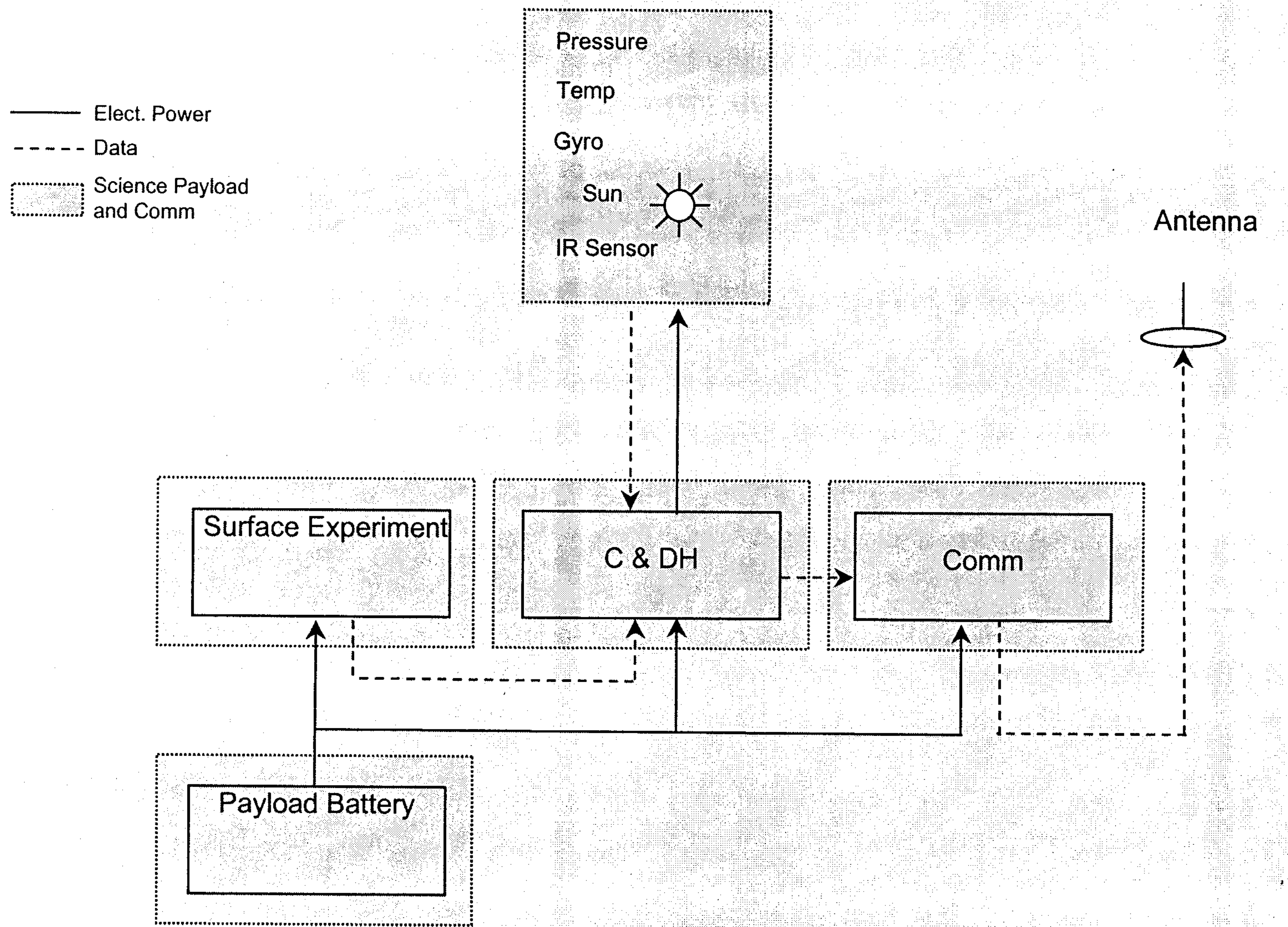
Seedwing System Diagram (typ)



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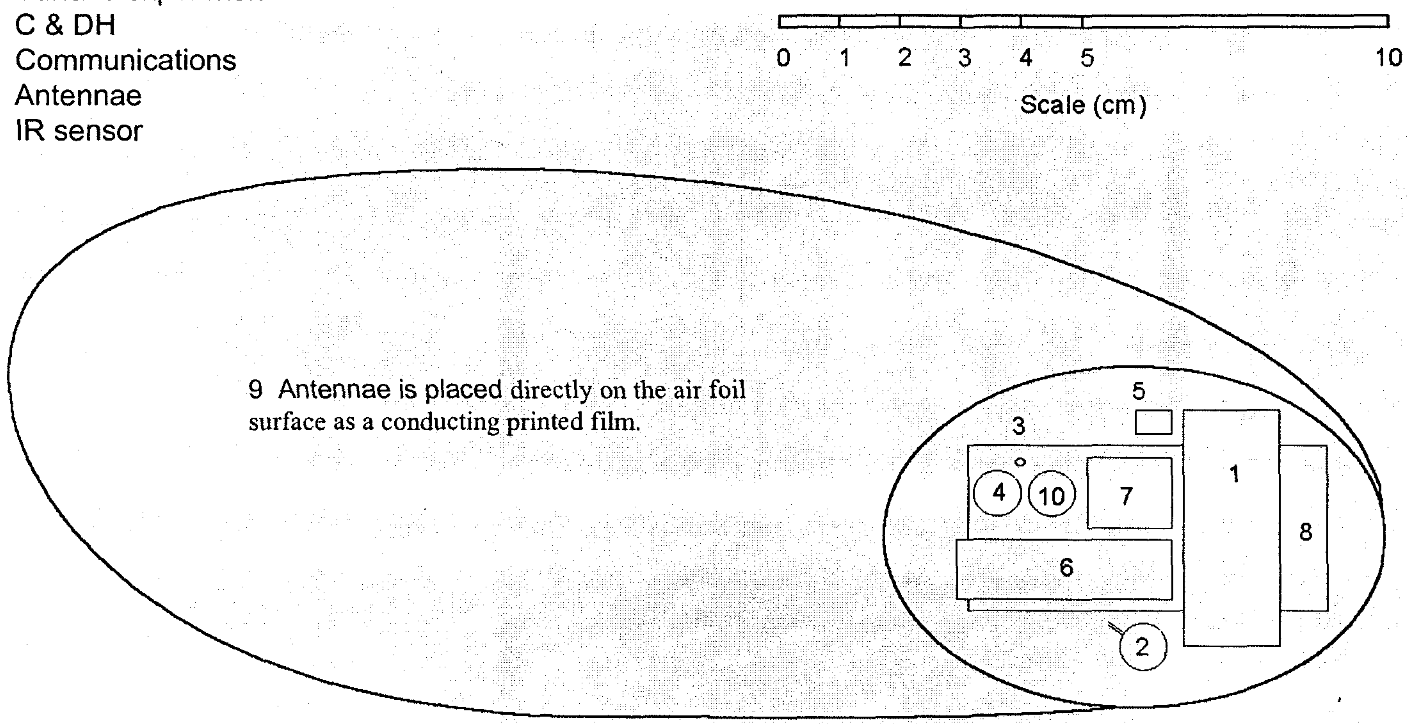
60 gm Seedwing Internal Arrangement

System Components

1. Battery, Li 400mAh
2. Static pressure sensor
3. Temperature sensor
4. Solar irradiance sensor
5. Spin rate sensor (2)
6. Surface experiment
7. C & DH
8. Communications
9. Antennae
10. IR sensor



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